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Canadian Science Advisory Secretariat
Science Advisory Report 2007/054

STOCK ASSESSMENT REPORT ON SCALLOPS (*PLACOPECTEN MAGELLANICUS*) IN SCALLOP PRODUCTION AREAS 1 TO 6 IN THE BAY OF FUNDY

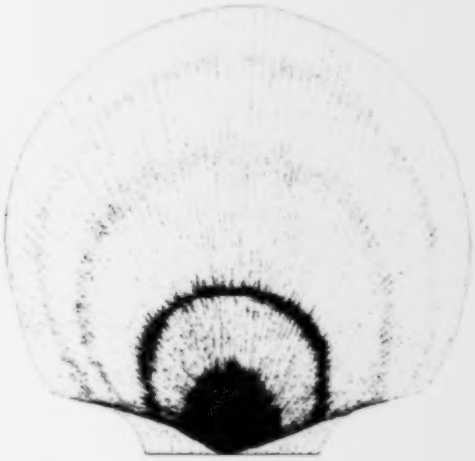


Figure 1. Scallop Production Areas in the Bay of Fundy. Refer to full detail map in Appendix 1 for place names.

Context

The Bay of Fundy area is fished by three scallop fleets: the Full Bay Fleet, the Mid Bay Fleet, and the Upper Bay Fleet. Full Bay vessels are 45' to 65' while Mid Bay and Upper Bay vessels are generally between 30' to 45'. Full Bay licensed vessels are permitted to fish throughout the Bay of Fundy. The Mid Bay license holders have access to the New Brunswick side and portions of the Nova Scotia side of the Bay of Fundy to the Mid Bay line and a portion of Scallop Production Area (SPA) 2. The Upper Bay licence holders are restricted to the upper reaches of the bay. The fishery has been managed using limited entry, gear size limits, seasonal closures, minimum shell height, meat count and individual meat weight restrictions. The gear width limit is 5.5 m with a ring size of not less than 82 mm inside diameter. Quotas were introduced in 1997. The Full Bay Fleet operates under an Individual Transferable Quota (ITQ) system while the Mid and Upper Fleets fish with competitive quotas. Total allowable catches (TACs) are set and landings are reported in terms of meat weights (adductor muscles).

Scallops in Scallop Production Areas 1 to 6 in the Bay of Fundy are assessed annually according to a framework conducted in 2002.

Canada

SUMMARY

All of Bay of Fundy

- Delayed reporting (logbooks) by the Mid and Upper Bay fleets, although improving, continues to be a problem.
- As there is no observer coverage of the scallop fleets in SPA 1 to 6, there was no means to estimate bycatch of non-scallop species.
- The total number of stations covered in the Bay of Fundy and Approaches in 2007 was 703, less than the 855 stations in 2006 but still above the number of stations in recent previous years (520 to 645).
- In 2006, attention was focused on the decline in meat weight-at-shell height seen across most areas in the Bay of Fundy and Approaches and the observation that in all areas the average meat weight was below the high recorded in 2001. This year, meat weights have increased and are now close to, or in some cases higher than, the 2001 means.

SPA 1A

- Landings were 168 t against a TAC of 150 t for the 2006/2007 season. An interim TAC of 100 t for the 2007/2008 season was recommended at the 2006 Inshore Scallop Advisory Committee meeting based on the 2006 assessment advice.
- Commercial catch rates have been declining from a recent peak in 2002.
- Since the 1998 year-class recruited to the fishery in this area, recruitment has been minimal and the abundance of commercial size scallops has been fished down.
- There may be above average recruitment in the 8 to 16 mile area along its border with SPA 4 in two to three years, otherwise recruitment is expected to be below average in the SPA 1A area.
- Population biomass estimated to be 1245 t (meats) in 2007 has increased over the estimate for 2006 (1233 t) and is above the median biomass of 1080 t (1997 to 2006).
- A total catch of 150 t in 2007/2008 is expected to result in a probability of 0.16 that exploitation rates will be greater than 0.20. This catch level is expected to result in no change in biomass between 2007 and 2008 assuming that meat weight-at-shell height does not change over that time. Given a catch of 150 t in 2007/2008, a total catch of 150 t in 2008/2009 should result in a probability of 0.30 that the exploitation rate will exceed 0.20.

SPA 1B

- Landings were 220 t against a TAC of 200 t for the Full Bay Fleet in the 2006/2007 season, and 173 t against a TAC of 200 t for the Mid and Upper Bay fleets in the 2007 season.
- Commercial catch rates have either increased slightly (Full Bay and Mid Bay) or stayed the same (Upper Bay) in 2007 relative to the last four years and all are above the low levels of the mid to late 1990s.
- Pre-recruits observed in the 2004 and 2005 survey near the Mid Bay/Upper Bay line are now recruiting to the commercial fishery.
- There is no evidence of any above average recruitment for the next two to three years.
- Population biomass estimated to be 2380 t (meats) in 2007 has increased over the estimate for 2006 (1983 t) and is above the median biomass of 2006 t (1997 to 2006).
- A total catch of 400 t in 2007/2008 is expected to result in a probability of 0.38 that exploitation rates will be greater than 0.20. This catch level is expected to result in a 9% increase in biomass between 2007 and 2008 assuming that meat weight-at-shell height

does not change over that time. Given a catch of 400 t in 2007/2008, a total catch of 400 t in 2008/2009 should result in a probability of 0.39 that the exploitation rate will exceed 0.20.

SPA 2

- This area is considered to be marginal habitat for scallops and is not monitored regularly. SPA 2 was last assessed in 2006 (DFO 2007).

SPA 3

- Landings in 2006/2007 were 119 t against a TAC of 200 t. An interim TAC of 50 t was set for October of the 2007/2008 season preliminary landings were 13 t (Quota Cap report 26 November 2007).
- Commercial catch rate has declined in this area since the high of 2003 and the 2007 estimate of 14.6 kg/h is just above the long-term median.
- The small increase in the 2007 survey biomass estimate for commercial size scallops over the 2006 biomass estimate was probably due to the increase in meat weight only, as mean numbers per tow stayed the same over the two years.
- The 2007 survey estimated higher than average abundances of scallops in the 10 to 40 mm size range in the Brier/Lurcher area. Better estimates of the strength of this year-class should be available from the 2008 survey. Measures to enhance protection of these pre-recruits should be considered.
- Population biomass estimated to be 449 t in 2007 has decreased over the estimate for 2006 (537 t) and is below the median biomass of 638 t (1996–2006).
- A total catch of 50 t in 2007/2008 is expected to result in a probability of 0.29 that exploitation rates will be greater than 0.20. This catch level is expected to result in a 9% decrease in biomass between 2007 and 2008 assuming that meat weight-at-shell height does not change over that time.

SPA 4

- Total landings in 2006/2007 were 68 t against a TAC of 100 t. An interim TAC of 100 t for the 2007/2008 season was recommended at the 2006 Inshore Scallop Advisory Committee meeting based on the 2006 assessment advice.
- Commercial catch rate in 2006/2007 was unchanged from 2005/2006 at 11.38 kg/h. The increased catch rate observed in October 2007 (15.9 kg/h) may be due to increased meat weight at shell height.
- The survey biomass estimate indicates that there was little change in biomass in 2007 relative to 2006 and that the current population levels are similar to those in the mid-1990s with below average recruitment expected in the upcoming year.
- The mean numbers of scallops with 20–50 mm shell height in 2007 were three times greater than the mean number in 2006, but were well below the densities observed for the 1998 year-class at the same size. These scallops are probably two year-olds and will not recruit to the fishery until 2009/2010.
- Population biomass estimated to be 712 t (meats) in 2007 has increased over the estimate for 2006 (672 t) and is below the median biomass of 835.1 t (1983 to 2006).
- A total catch of 100 t in 2007/2008 is expected to result in a probability of 0.44 that exploitation rates will be greater than 0.20. This catch level is expected to result in an 8% increase in biomass between 2007 and 2008 assuming that meat weight-at-shell height does not change over that time. Given a catch of 100 t in 2007/2008, a total catch of 100 t in 2008/2009 should result in a probability of 0.46 that the exploitation rate will exceed 0.20.

SPA 5

- Landings in 2007 were 3.8 t against a TAC of 10 t.
- Commercial catch rate in 2007 (10.8 kg/h) was lower than that observed for 2006 (12.5 kg/h) and below the long term median of 19.8 kg/h (1977–2006).
- The mean number per tow of commercial size scallops in 2007 (131/tow) is above the 1997–2006 median (120/tow) but little recruitment is expected for the next two years.
- The TAC for 2008 should not exceed the average catch of 10 t over the period 1997 to 2007 (excluding the high catch in 2004).

SPA 6

- Landings to 26 November 2007 were 68 t against a TAC of 140 t.
- The Mid Bay catch rate may be a better reflection of population trends than the Full Bay catch rate as it is based on somewhat higher levels of effort; however, this index does not indicate any large changes in the last 10 years. The abundance of commercial size scallops appears to remain unchanged from 2006 in SPA 6A and 6B and has possibly declined in SPA 6C. Above average recruitment was detected in SPA 6A and 6B; however, in the case of the latter, this recruitment appears to be confined to Duck Island Sound.
- There is no evidence to advise increasing the TAC over its current level.

BACKGROUND

Species Biology

The sea scallop (*Placopecten magellanicus*) occurs only in the northwest Atlantic from Virginia north to Labrador. Within this area, scallops are concentrated in persistent, geographically discrete aggregates or "beds", many of which support valuable commercial fisheries. The larger beds are found offshore and in the Bay of Fundy. Scallops exhibit varying growth rates and meat yields in different beds and in different areas of large beds.

Unlike many commercial scallop species, the sea scallop has separate sexes. Male scallops develop a white gonad in the summer months, while female gonads are bright red. Eggs and sperm are released into the water where fertilization takes place. Spawning begins in late August to early September, and the larvae drift in the water column for almost a month before settling to the bottom.

Rationale for Assessment

A meeting of the Regional Advisory Process was held 5 December 2007 at the Bedford Institute of Oceanography in Dartmouth, N.S., to review the 2007 scallop fishery and assess the status of the scallop stocks in Scallop Production Areas 1 to 6 in the Bay of Fundy as well as to provide scientific advice for the 2008 fishery. Specifically, the meeting addressed:

The assessment of the status of the scallop stocks, including:

- An analysis of all available commercial and survey information.
- For SPA 1 (8 to 16 mile Digby Area) and SPA 4, application of the assessment model described in Smith and Lundy (2002).
- For SPA 1 (8 to 16 mile Digby Area) and SPA 4, review of interim advice provided for 2007/2008 and recommendations for 2008/2009.
- For the rest of SPA 1, SPA 3, SPA 5 and SPA 6, the provision of advice for 2008.
- For all areas, estimates of bycatch of non-scallop species in the 2007 fishery.

ASSESSMENT, CONCLUSION AND ADVICE

SPA 1 – Inner/Upper Bay of Fundy

SPA 1 covers most of the mid to inner Bay of Fundy. Since 2002, it has been managed as two separate areas: SPA 1A and SPA 1B (refer to detailed map in Appendix 1). SPA 1 is fished to varying levels by all three fleets. The Full Bay Fleet can fish throughout all of SPA 1A and 1B. However, the other fleets are restricted to SPA 1B, the Mid Bay Fleet fishing only north of the Mid Bay line, and the Upper Bay Fleet fishing only east of the Upper Bay line.

SPA 1A – Southwest Bay of Fundy

Fishery

Landings were 168 t for the Full Bay Fleet during the 2006/2007 fishing year against a quota of 150 t (Table 1). This was down from 814 t in 2002/2003 and below the average (1998–2007) of recent landings (Figure 2). An interim TAC of 100 t was for the 2007/2008 season was recommended at the 2006 Inshore Scallop Advisory Committee meeting based on the 2006 assessment advice. As of the Quota Cap report of 26 November 2007, 42 t had been landed from SPA 1A against this interim TAC.

Table 1: Landings and TAC (meats, t) for SPA 1A for the Full BayFleet.

Year	Avg. 98–02	2002/ 2003[1]	2003/ 2004	2004/ 2005	2005/ 2006	2006/ 2007	2007/ 2008[2]
TAC (t)	NA	1200	700	400	100	150	100
Landings (t)	182	814	462	304	180	168	42

[1] Full Bay TAC was split into SPA 1A and SPA 1B in 2002/03. Quotas and landings for 1998–2001/2002 are for all SPA 1; those for 2002/2003 to 2006/2007 are for SPA 1A only.
[2] Interim TAC, landings to 26 November 2007.

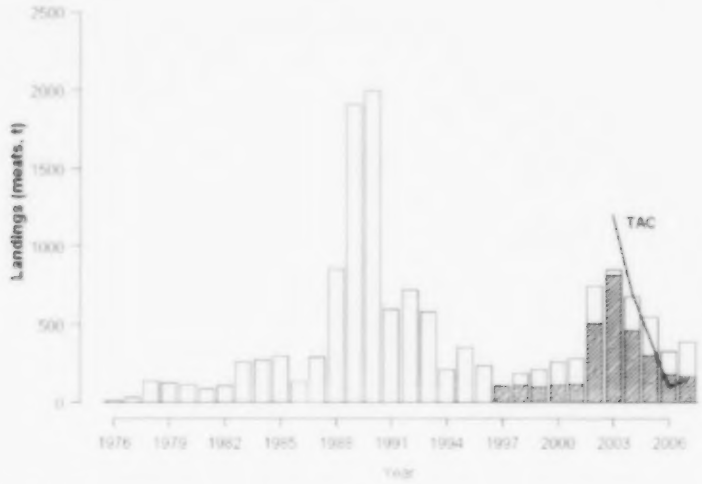


Figure 2. Scallop landings and TAC (meats, t) in SPA 1A (shaded bars). Open bars represent landings by the Full Bay Fleet in SPA 1 as a whole. TAC for SPA 1A only.

Resource Assessment

The commercial catch rate in SPA 1A declined from a high in the late 1980s to a low in 1997. With the large 1998 year-class recruiting to SPA 1A, it peaked again in 2002, and has been declining since then (Figure 3).

Average meat weights sampled from the catch during 2006/2007 were similar to those sampled during the 2005/2006 fishing season and are consistent with fishing on an older population with little recruitment.

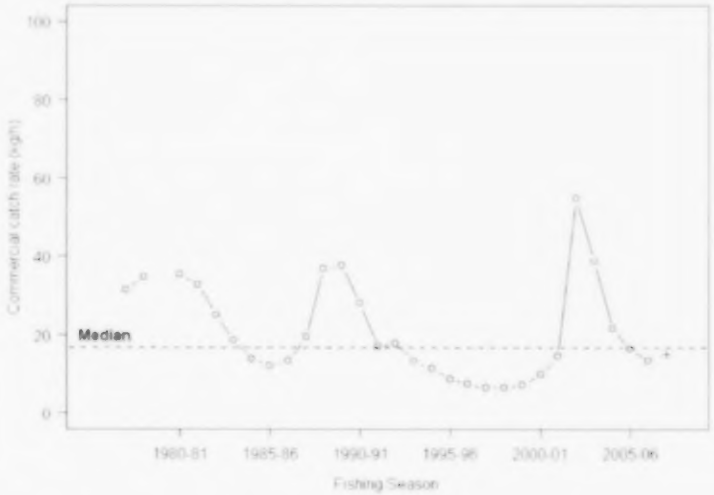


Figure 3. Commercial catch rate (kg/h) from the Full Bay Fleet for scallops in SPA 1A.

In SPA 1A, resource surveys have been conducted annually since 1981 in the 8 to 16 mile area off of Digby, Nova Scotia. Up to 2003, the surveys were conducted in May–June, but the expanding distribution of lobster traps in the area necessitated rescheduling the survey to August–September. The survey vessel had mechanical problems in 2004, resulting in a shortened survey in September–October. Since 2005, survey coverage has been consistent in

the 8 to 16 mile area. Since the 1998 year-class recruited to the fishery in this area, recruitment has been minimal and the abundance of commercial size scallops has been fished down (Figure 4). While there are higher than average densities of scallops in the 20 to 40 mm range (mainly along the SPA 4 border), the strength of this year-class (possibly 2006) can not be evaluated until next year when the animals are larger and more available to the survey gear.

Annual survey tows have also been conducted in the 2 to 8 mile Young's Cove and Hampton strata (east of SPA 4) since 1984. This survey series indicates that the large 1984 and 1985 year classes seen in the 8 to 16 mile survey and SPA 4 were also abundant in this area, although the 1998 year-class does not appear to have been as strong here as in those other survey areas (Figure 5).

There has been an increasing amount of survey coverage in the parts of SPA 1A outside of the 8 to 16 mile area and the 2 to 8 mile Young's Cove and Hampton strata in recent years (this 'outside' area will be referred to as the Middle Bay South area). During 1997–2006, a range of 2 to 41 survey tows have occurred annually in this area (an exception is 2003 during which no tows were conducted). The strong 1998 year-class was not observed in the survey here, but the commercial size index did increase in 2002 when this year-class was recruiting in the other areas of SPA 1A (Figures 6 and 7). There appears to have been an increase in 2005 and 2006 possibly due to recruits caught in the 2005 survey.

Average meat weight-at-shell height in the survey has increased in the 8 to 16 mile and 2 to 8 mile and while staying the same in the Middle Bay South area.

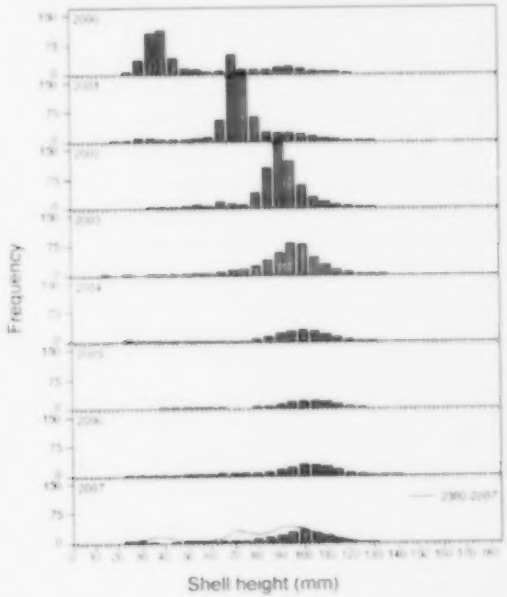


Figure 4. Scallop shell height frequencies (mean no./tow) from surveys of the 8 to 16 mile area of SPA 1A. Surveys were conducted in June during 1981–2003 and in August/September during 2004–2007.

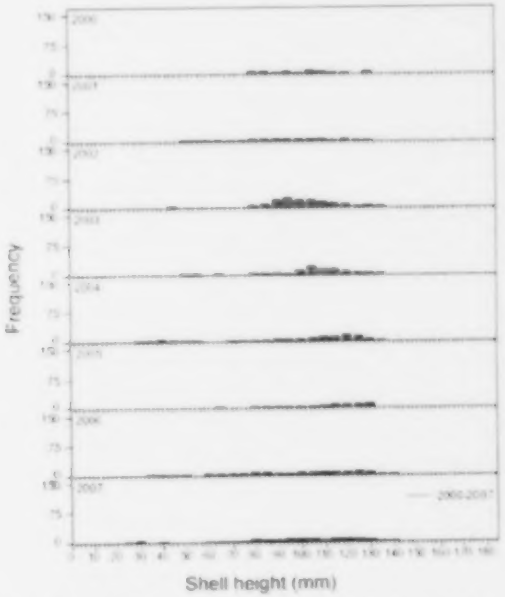


Figure 5. Scallop shell height frequencies (mean no./tow) from surveys of the 2 to 8 mile area of SPA 1A. Surveys were conducted in June during 1984-2003 and in August/September during 2004-2007.

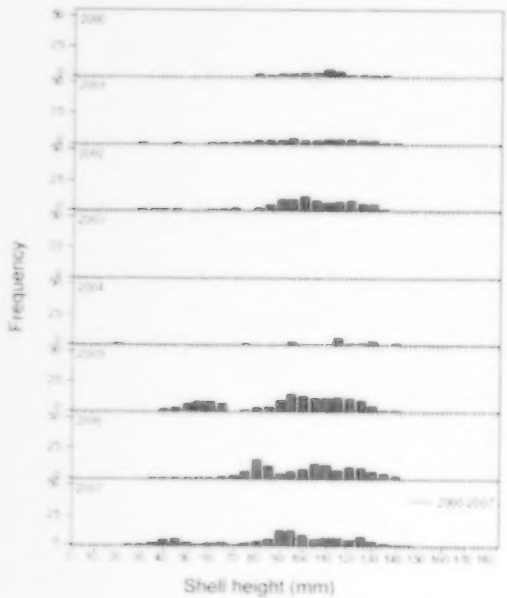


Figure 6. Scallop shell height frequencies (mean no./tow) from surveys of Middle Bay South area of SPA 1A. Surveys were conducted in June during 1997–2002 and in August/September during 2004–2007.

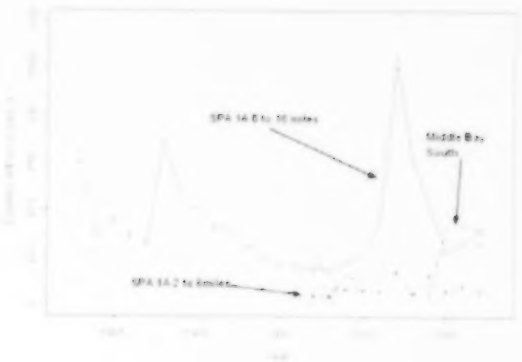


Figure 7. Survey biomass index (meats, t) for commercial size (≥ 80 mm shell height scallops in the 8 to 16 mile area, 2 to 8 mile and Middle Bay South area of SPA 1A.

The population model described in Smith and Lundy (2002) was applied to the combined survey biomass data (Figure 7) for the three surveys in this area along with the catch data over the 1997–2007 period. An average of the 2002 and 2004 biomass estimates for the Middle Bay South area was used to estimate the biomass in 2003. A constant growth model was assumed while annual meat weight/shell height relationships were used for each survey. Population biomass estimated to be 1245 t (meats) in 2007, has increased over the estimate for 2006 (1233 t) and is above the median biomass of 1080 t (1997 to 2006).

Evaluation of the model's forecasting ability indicated that the model fit the data well and appears to have captured the dynamics of this population in the short term (Figure 8). The forecast for 2008 was made assuming a catch of 150 t in 2007/2008 and is also dependent upon the average meat weight-at-shell height being similar to that observed in 2007.

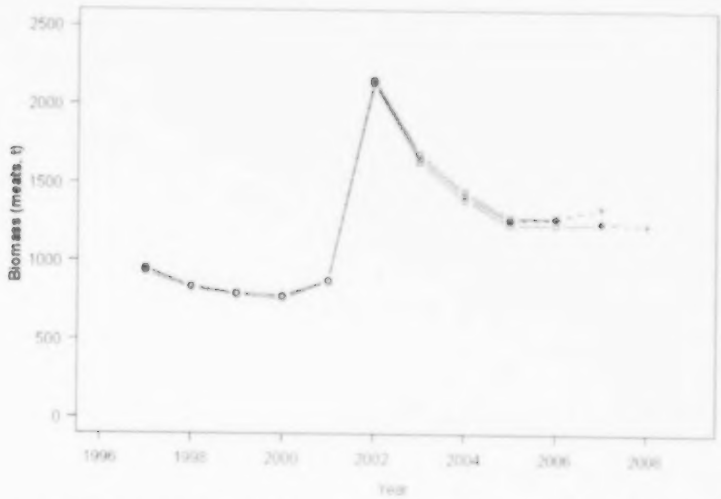


Figure 8. Comparison of population biomass estimates of commercial size scallops (≥80 mm shell height) from the delay-difference population model for data up to 2005, 2006 and 2007, respectively for SPA 1A. Predictions from the model for 2006, 2007 and 2008 indicated by dashed lines and crosses. Prediction for 2008 was made assuming a 2007/2008 catch of 150 t.

- Conclusions and Advice

In a previous assessment, exploitation rate (e) was suggested as an appropriate fishery indicator with an upper limit reference point of 0.2 based on empirical evidence from earlier work (DFO 2004). A total catch of 150 t in 2007/2008 is expected to result in a probability of 0.16 that exploitation rates will be greater than 0.20 (Table 2). This catch level is expected to result in no change in biomass between 2007 and 2008 assuming that meat weight-at-shell height does not change over that time. Given a catch of 150 t in 2007/2008, a total catch of 150 t in 2008/2009 should result in a probability of 0.30 that the exploitation rate will exceed 0.20.

Table 2. Decision table to evaluate catch levels with respect to posterior probability of exceeding exploitation rate of 0.2 for 2007/2008 and 2008/2009.

		Catches in 2008/2009			
Catch in	Pr(e≥0.2)	Pr(e≥0.2) (exploitation)			
2007/08	(exploitation)	75 t	100 t	150 t	200 t
100 t	0.01 (0.09)	0.03 (0.07)	0.08 (0.09)	0.26 (0.14)	0.46 (0.19)
150 t	0.16 (0.14)	0.04 (0.07)	0.10 (0.10)	0.30 (0.15)	0.50 (0.20)
200 t	0.43 (0.19)	0.05 (0.08)	0.13 (0.11)	0.34 (0.16)	0.53 (0.21)
250 t	0.60 (0.24)	0.08 (0.09)	0.17 (0.11)	0.39 (0.17)	0.57 (0.22)

There may be above average recruitment in the 8 to 16 mile area along its border with SPA 4 in two to three years, otherwise recruitment is expected to be below average in the SPA 1A area.

SPA 1B – Norther/Upper Bay of Fundy

Fishery

In 2006/2007, the Full Bay Fleet landed 220 t against a quota of 200 t (Table 3). The Mid and Upper Bay fleets had a shared quota of 200 t and their combined landings were 173 t (Table 4, Figure 9).

Table 3. Landings (meats, t) in SPA 1B for the Full Bay fleet.

Year	Avg. 98–02	2002/ 2003[1]	2003/ 2004	2004/ 2005	2005/ 2006	2006/ 2007	2007/ 2008[2]
TAC (t)	NA	100	200	200	225	200	50
Landings	210	33	210	228	145	220	15

[1] Full Bay TAC was split into SPA 1A and SPA 1B in 2002/03.
[2] Interim TAC, landings to 26 November 2007

Table 4. Landings and TAC (meats, t) in SPA 1B for Mid (MB) and Upper Bay (UB) fleets.

Year	Avg. 98–02	2003	2004	2005	2006	2007
TAC (t)	NA	150	150	200	225	200
Landings: MB	39	145	166[1]	153	137	93
Landings: UB	13	61	85	51	49	80

[1] Remaining quotas in SPAs 1 and 6 combined 2 August 2004 with most of the combined quota coming from SPA 1.

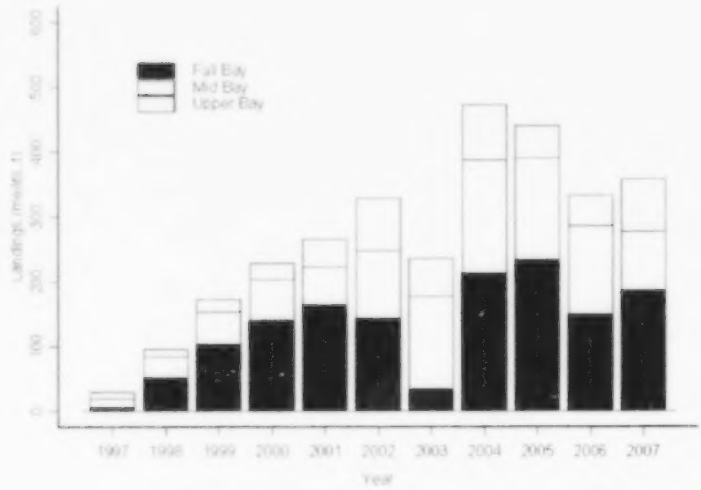


Figure 9. Scallop landings and TAC (meats, t) in SPA 1B (for all fleets).

Resource Assessment

Commercial catch rates have either increased slightly (Full Bay and Mid Bay) or stayed the same (Upper Bay) in 2007 relative to the last four years and all are above the low levels of the mid to late 1990s (Figure 10).

Meat weights sampled from the Full Bay, Mid Bay, and Upper Bay fleets' catches during 2007 were similar to those reported for the previous year in all three areas (Cape Spencer, Middle Bay North, and Upper Bay).

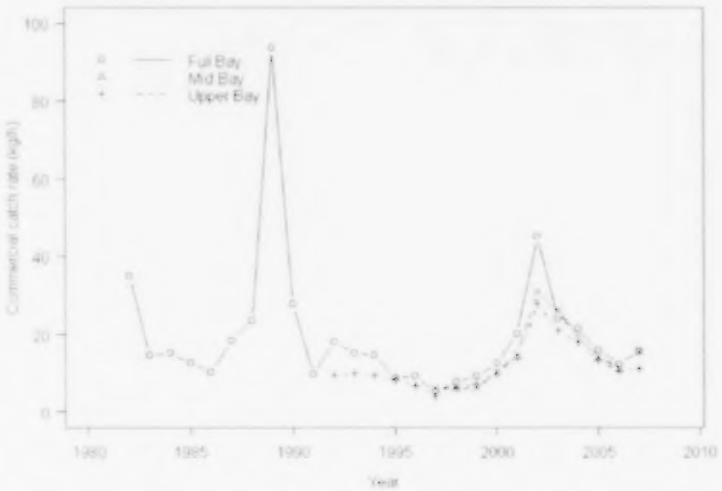


Figure 10. Commercial catch rate (kg/h) for scallops in SPA 1B.

In SPA 1B, resource surveys have not covered the whole area consistently. Surveys off of Digby were expanded to the Cape Spencer grounds in 1996, and the Upper Bay area was added after 2000. The part of SPA 1B that is within SFA 28B and outside of Cape Spencer (Middle Bay North area) has been covered as time permitted. Due to research vessel problems, the 2004 survey only covered the Cape Spencer grounds and six stations in the Middle Bay North area. Since 2005, the survey has been conducted by a commercial vessel and coverage in SPA 1B has been more extensive than in previous years.

In the Cape Spencer area, there has been one above average year-class (2001 or 2002) in the survey series that started recruiting to the commercial fishery in 2006 and now appears to be fully recruited (Figure 11). There is no evidence of any above average recruitment for the next two to three years.

In the remaining part of SPA 1B that is within SFA 28B (Middle Bay North area), a range of 6 to 69 survey tows have been conducted annually since 1997. Pre-recruits observed in the 2004 and 2005 survey and now recruiting to the commercial fishery (Figure 12) were mainly located in an area near the Mid Bay/Upper Bay line (Figure 13). These pre-recruits were also observed in the Upper Bay survey in 2005 in the same area (Figure 14).

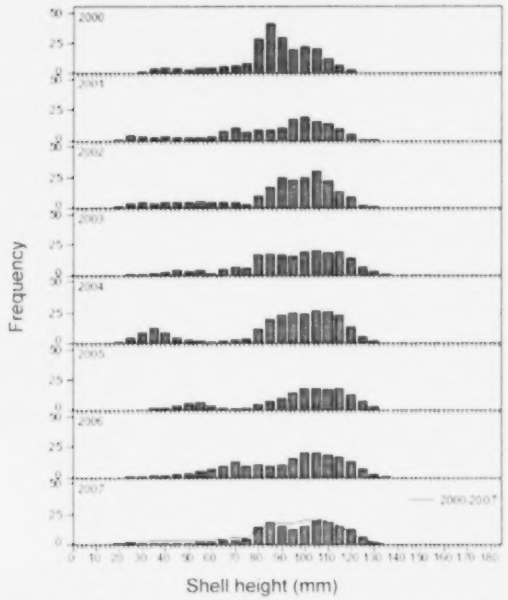


Figure 11. Scallop shell height frequencies (mean no./tow) from surveys of the Cape Spencer area of SPA 1B.

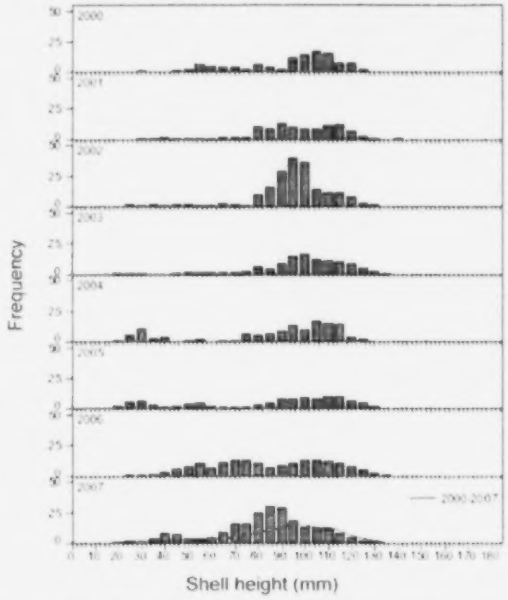


Figure 12. Scallop shell height frequencies (mean no./tow) from surveys of the Middle Bay North area of SPA 1B.

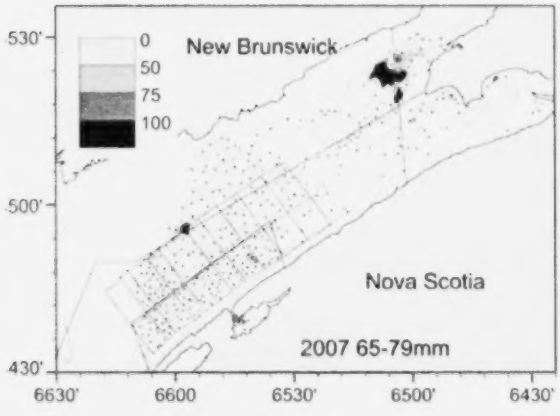


Figure 13. Spatial distribution of scallop catches from the 2007 survey of SPAs 1 and 4 for recruit size (65–79 mm shell height) scallops. Positions of tow locations are indicated.

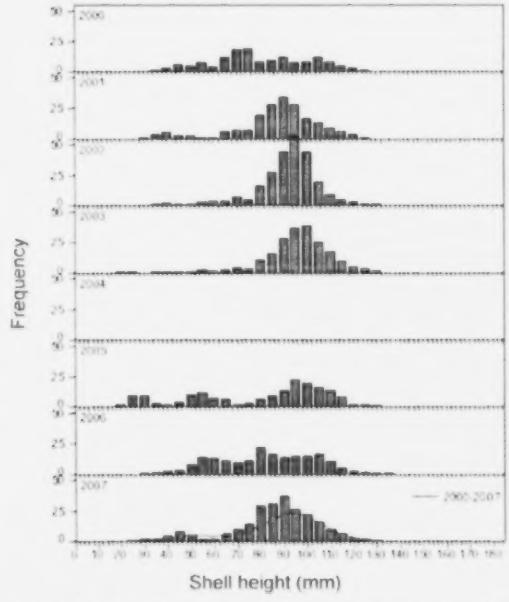


Figure 14. Scallop shell height frequencies (mean no./tow) from surveys of the Upper Bay area of SPA 1B.

The population model described in Smith and Lundy (2002) was applied to the combined survey biomass data (Figure 15) for the three surveys in this area along with the catch data over the 1997–2007 period. An average of the 2003 and 2005 biomass estimates for the Upper Bay

area was used to estimate the biomass in 2004. The Middle Bay North biomass estimates for 1997 to 2000 were used to fill in for the missing biomass estimates in the Upper Bay series based on the similarity of the two series in the years when both surveys occurred. A constant growth model was assumed while annual meat weight/shell height relationships were used for each survey. Population biomass estimated to be 2380 t (meats) in 2007 has increased over the estimate for 2006 (1983 t) and is above the median biomass of 2006 t (1997 to 2006).

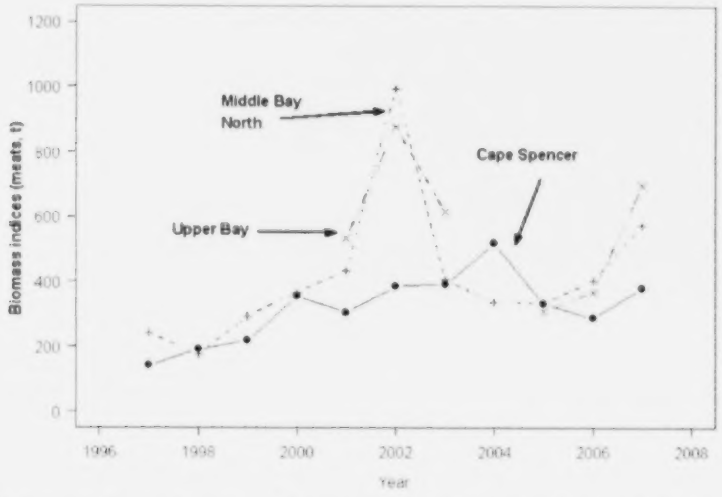


Figure 15. Survey biomass index (meats, t) for commercial size (≥ 80 mm shell height) scallops in the Cape Spencer area, Middle Bay North area and Upper Bay area of SPA 1B.

Average meat weight-at-shell height has increased in all three survey areas in SPA 1B by 20–30%.

Evaluation of the model's forecasting ability indicated that the model has been affected by the large changes in meat weight-at-shell height in this area (Figure 16). The forecast for 2008 was made assuming a catch of 400 t in 2007/2008 and is also dependent upon the average meat weight-at-shell height being similar to that observed in 2007.

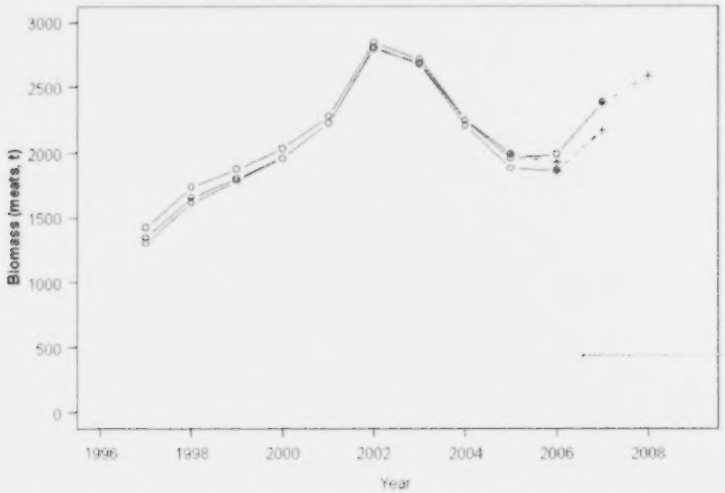


Figure 16. Comparison of population biomass estimates of commercial size scallops (≥80 mm shell height) in SPA 1B from the delay-difference population model for data up to 2005, 2006 and 2007, respectively. Predictions from the model for 2006, 2007 and 2008 indicated by dashed lines and crosses. Prediction for 2008 was made assuming a 2007/2008 catch of 400 t.

Conclusions and Advice

Potential catches for 2007/2008 and 2008/2009 are evaluated for SPA 1B in a manner similar to SPA 1A. A total catch of 400 t in 2007/2008 is expected to result in a probability of 0.38 that exploitation rates will be greater than 0.20 (Table 5). This catch level is expected to result in a 9% increase in biomass between 2007 and 2008 assuming that meat weight-at-shell height does not change over that time. Given a catch of 400 t in 2007/2008, a total catch of 400 t in 2008/2009 should result in a probability of 0.39 that the exploitation rate will exceed 0.20.

Table 5. Decision table to evaluate catch levels with respect to posterior probability of exceeding exploitation rate of 0.2 for 2007/2008 and 2008/2009.

		Catches in 2008/2009			
Catch in	Pr(e≥0.2)	Pr(e≥0.2) (exploitation)			
2007/08	(exploitation)	300 t	400 t	450 t	500 t
300 t	0.08 (0.14)	0.17 (0.13)	0.36 (0.17)	0.45 (0.21)	0.54 (0.21)
400 t	0.38 (0.18)	0.20 (0.13)	0.39 (0.17)	0.49 (0.22)	0.57 (0.22)
450 t	0.55 (0.21)	0.22 (0.14)	0.42 (0.18)	0.51 (0.23)	0.59 (0.23)
500 t	0.66 (0.23)	0.23 (0.14)	0.43 (0.18)	0.53 (0.23)	0.61 (0.23)

SPA 3 – Brier Island, Lurcher Shoal, and St. Mary's Bay

Fishery

Although scallops can be found throughout most of this area, there are three main beds, those around Lurcher Shoal, below Brier Island, and in St. Mary's Bay. St. Mary's Bay (formerly SPA 7) was combined with SPA 3 for a combined TAC starting in 1999 for management. The lobster fishery influences the scallop fishing season throughout this area.

Landings in SPA 3 increased each year from 1991 to 1994, reaching a high of 1439 t (Figure 17). Landings declined from 1995 until 1998. However, there is uncertainty about the landings from 1991 to 1996 due to misreporting.

Landings for the 2006/2007 fishing year were 119 t against a TAC of 200 t (Table 6). An interim TAC of 50 t was set for October of the 2007/2008 fishing season and preliminary landings were 13 t (Quota Cap report, 26 November, 2007).

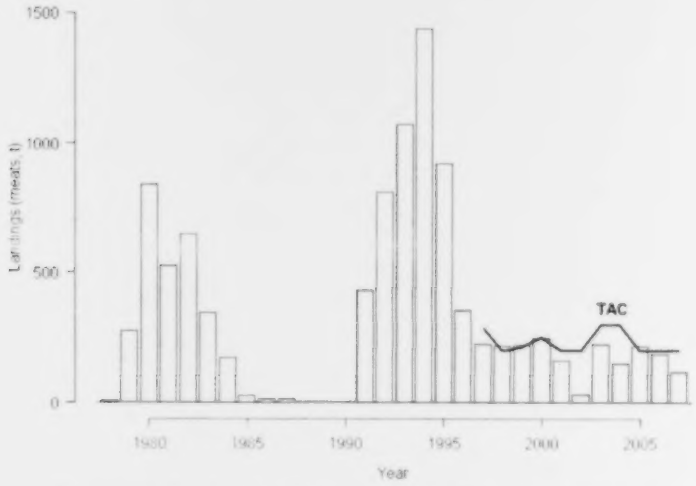


Figure 17. Scallop landings and TAC (meats, t) in SPA 3.

Table 6. Landings and TAC (meats, t) for SPA 3

Year	Avg. 98–02	2003	2004	2005	2005/ 2006	2006/ 2007	2007/ 2008[1]
TAC	213	200	300	300	200	200	50
Landings	177	225	151	208	174	119	13

[1] Interim TAC, preliminary landings to 26 November 2007.

Resource Assessment

Commercial catch rate has declined in this area since the high of 2003, and the 2007 estimate of 14.6 kg/h is just above the long-term median (1996–2006; Figure 18). October catch rates are also just above the median. Effort declined in 2007 relative to recent years.

Relatively few meat weight samples were collected in SPA 3 during 2006/2007. The available data suggest that meat counts for 2006/2007 were similar to those reported for the previous fishing season.

Annual research vessel surveys have been conducted around Brier Island and Lurcher Shoal each August from 1991 to 2003. Surveys in SPAs 1 and 4 were re-scheduled to August since 2004 to avoid interaction with lobster gear in June. As a result, the survey in SPA 3 has been conducted in June since 2004. Due to differences in coverage and design, only the results from the 1996 to 2006 surveys are comparable.

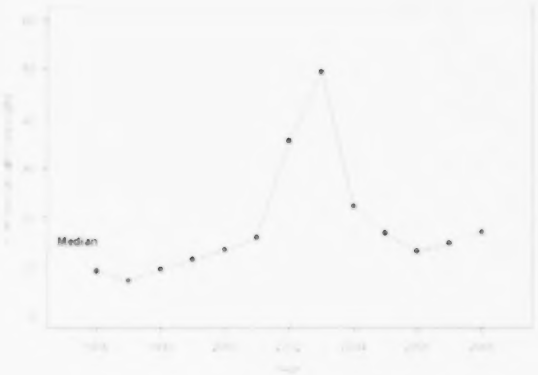


Figure 18. Commercial catch rate (kg/h) for scallops in SPA 3. Estimate for 2008 based on October 2007 catch rates only.

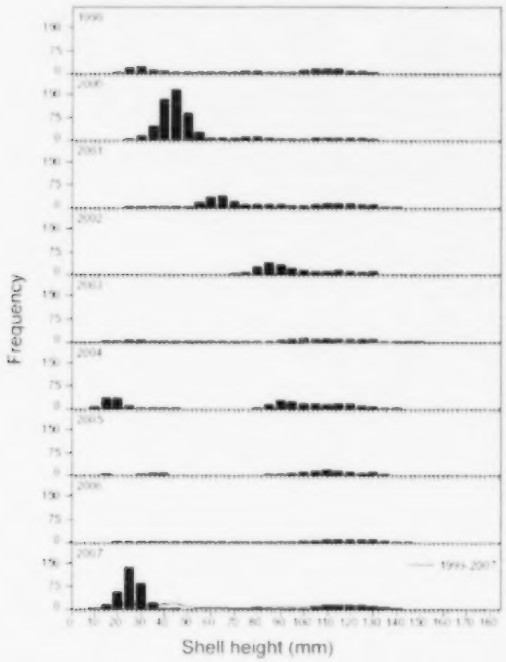


Figure 19. Scallop shell height frequencies (mean no./tow) from surveys of the Brier/Lurcher portion of SPA 3

The 2007 survey estimated higher than average abundances of scallops in the 10 to 40 mm size range in the Brier/Lurcher area (Figure 19). Estimates of scallops in this size range are usually interpreted as being more indicative than quantitative because of the 38 mm liner used in the lined gear. Indeed, signs of good recruitment in the past have not always developed into actual recruitment (e.g., estimates in 2000 and 2004). The important difference with the catches of pre-recruits in the 2007 survey was that the high catches were found closer inshore and over a wider area than usual. Better estimates of the strength of this year-class should be available from the 2008 survey once these scallops grow another year and become more available to the survey gear.

The St. Mary's Bay portion of SPA 3 has been surveyed since 1999 with no survey for 2002–2003 due to vessel constraints. A number of apparently strong year-classes have been detected in this survey, but these year-classes rarely survived in large numbers to reach commercial sizes (Figure 20). Densities of commercial size scallops in this area are less than one half those observed in the Brier/Lurcher area.

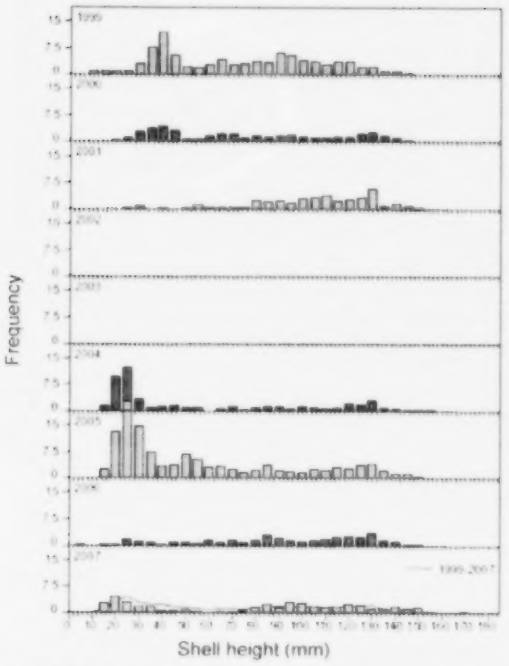


Figure 20. Scallop shell height frequencies (mean no./tow) from surveys of the St. Mary's Bay portion of SPA 3.

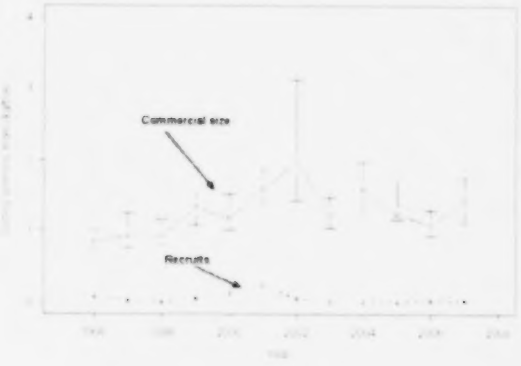


Figure 21. Survey biomass index (kg/tow) for commercial size (≥ 80 mm shell height) and recruit (65–79 mm shell height) scallops in the Brier/Lurcher portion of SPA 3. Commercial biomass index has 95% confidence intervals included. Surveys conducted in August until 2004 when the survey was changed to June.

Similar to areas in the Bay of Fundy, meat weight-at-shell height in 2007 increased in SPA 3 by approximately 10% over 2006.

An error was discovered in the 2006 estimated biomass presented in last year's assessment. The corrected results indicated a much more pessimistic view of stock status in 2006. A small increase in 2007 biomass estimate for commercial size scallops over the 2006 biomass estimate was mainly due to the increase in meat weight only, as mean numbers per tow stayed the same over the two years (Figure 21).

A delay-difference model (Smith and Lundy 2002) was fit to the survey data and commercial catch in SPA 3. While formulations of this model had performed poorly in the past, this year close attention was paid to the timing of the survey and the fishery which resulted in better fit of the model to the data. A constant growth model over time was assumed based on parameter estimates from 1996 data from the Brier/Lurcher area. Population biomass estimated to be 449 t in 2007 has decreased over the estimate for 2006 (537 t) and is below the median biomass of 638 t (1996–2006).

Evaluation of the model's forecasting ability indicated that the model has been affected by the changes in meat weight-at-shell height in this area (Figure 22). The population model predicts the biomass to June 2008 assuming that 20 t are removed between 1 October 2007 and 31 May 2008.

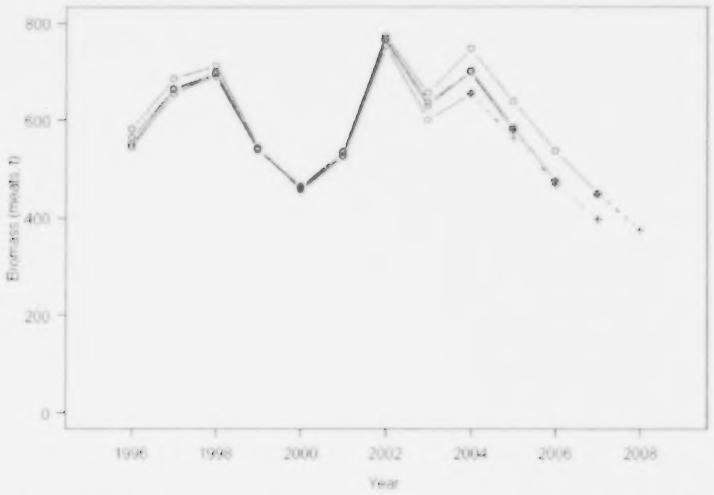


Figure 22. Comparison of population biomass estimates of commercial size scallops (≥ 80 mm shell height) from the delay-difference population model for data up to 2004, 2005, 2006 and 2007, respectively for SPA 3. Predictions from the model for 2005, 2006, 2007 and 2008 indicated by dashed lines and crosses. Prediction for 2008 made assuming a 2007/2008 catch of 20 t up to June 2008.

Conclusions and Advice

The model indicates that the 2006/2007 catch level resulted in a median exploitation of 0.36 with a probability of exceeding 0.2 of 0.83. Evaluation of the impact of various catch levels on the population are conducted assuming the remainder of the catch (i.e., minus 20 t) is removed starting in June through to the end of September (Table 7). A total catch of 50 t in 2007/2008 is expected to result in a probability of 0.29 that exploitation rates will be greater than 0.20. This catch level is expected to result in a 9% decrease in biomass between 2007 and 2008 assuming that meat weight-at-shell height does not change over that time.

Table 7. Decision table to evaluate catch levels with respect to posterior probability of exceeding exploitation rate of 0.2 for 2007/2008.

Catches in 2007/2008 (meats, t)	Median exploitation	$Pr(e_{2007}) \geq 0.2$	Expected decline in biomass (%)
50	0.13	0.29	8.7
100	0.32	0.68	27.1
150	0.52	0.84	47.0
200	0.71	0.89	70.3

The 2008 survey should provide a better estimate of the strength of the recruitment for 2009. Measures to enhance protection of these pre-recruits should be considered.

SPA 4 - Digby

Fishery

Landings in SPA 4 steadily declined from 1991 to 1995 as the remnants of large year-classes (1984, 1985) were fished down (Figure 23). Portions of what is now SPA 4 were closed in 1995 and 1996 because of low stock levels. The increase in landings starting in 2001 was due to the strong 1998 year-class recruiting to the fishery. In October 2001, fishing was restricted to the Digby Gut up the Bay to Parkers Cove to protect the abundant 1998 year-class. As this year-class grew and recruited to the fishery, fishing occurred throughout SPA 4.

The SPA 4 fishing season extends from 1 October to 30 April. Total landings in 2006/2007 were 68 t against a TAC of 100 t. An interim TAC of 100 t was for the 2007/2008 season was recommended at the 2006 Inshore Scallop Advisory Committee meeting based on the 2006 assessment advice. As of the Quota Cap report of 26 November 2007, 36 t had been landed from SPA 4 against this interim TAC.

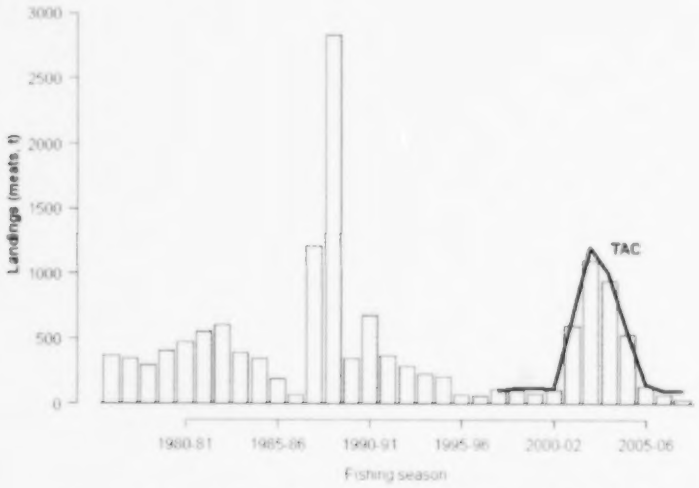


Figure 23. Scallop landings and TAC (meats, t) in SPA 4.

Table 8. Landings and TAC (meats, t) for SPA 4.

Year	Avg. 98–02	2002/ 2003	2003/ 2004	2004/ 2005	2005/ 2006	2006/ 2007	2007/ 2008[1]
TAC	250	1200	1000	550	150	100	100
Landings	221	1097	945	535	133	68	36

[1] Interim TAC, landings to 26 November 2007.

Resource Assessment

Effort has been declining in SPA 4 since the above average 1998 year-class was fished out. Commercial catch rate in 2006/2007 was unchanged from 2005/2006 at 11.38 kg/h (Figure 24). The increased catch rate observed in October 2007 (15.9 kg/h) may be due to increased meat weight-at-shell height.

In general, the fishery has continued concentrating on older, larger scallops for the last three years relative to meat weights observed in 2003/04.

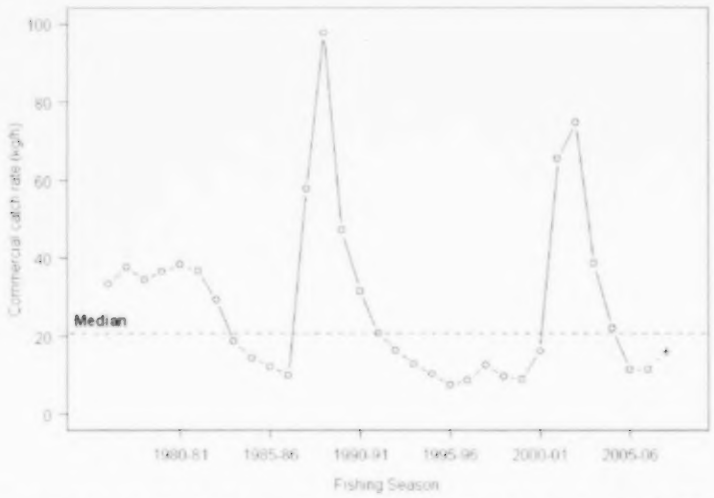


Figure 24. Commercial catch rate (kg/h) for scallops in SPA 4. Catch rate for 2007–2008 refers to October 2007 only.

Research vessel surveys have been conducted since 1981. Up to 2003, the surveys were conducted in June every year, but the expanding distribution of lobster traps in the area necessitated rescheduling the survey to August in 2004. However, survey vessel mechanical problems resulted in the 2004 survey being conducted in September. Since 2005, surveys of SPA 4 have been completed in August each year as planned.

Densities of scallops with shell heights 20–50 mm were four to five times higher in the Digby Gut to Gulliver's Head strata in 2007 compared to 2006. Over all strata, the mean numbers of scallops in this size class in 2007 were three times greater than the mean number in 2006, but were well below the densities observed for the 1998 year-class at the same size. (Figure 25). These scallops are probably two year-olds and will not recruit to the fishery until 2009/2010.

Preliminary survey estimates for 2007 were presented at a Full Bay Fleet meeting on 7 September 2007 that showed areas where large numbers of small scallops had been found. Subsequently, the Full Bay Fleet recommended a closed area to DFO encompassing the distribution of the small scallops in SPA 4 and the adjoining area in SPA 1 (Figure 26). This closure went into effect 2 October 2007 and will be re-evaluated after the 2008 survey.

The survey biomass estimate indicates that there was little change in biomass in 2007 relative to 2006. The current population levels are similar to those in the mid-1990s, with below average recruitment expected in the upcoming year (Figure 27). Similar to the other areas in the Bay of Fundy, average meat weight-at-shell height increased in SPA 4 in 2007.

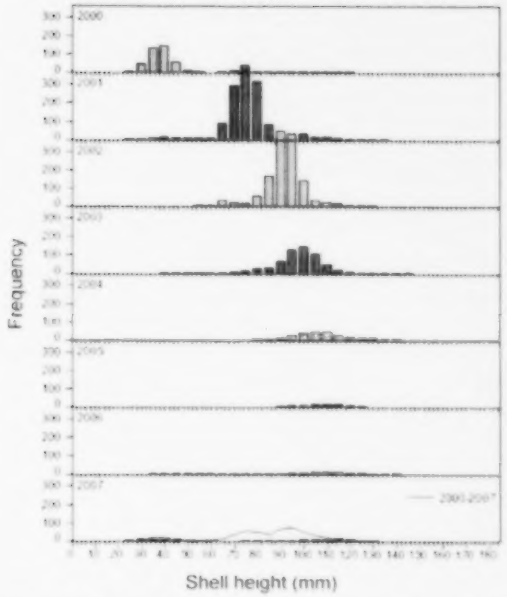


Figure 25. Scallop shell height frequencies (mean no./tow) from surveys of SPA 4. Surveys were conducted in June during 1981–2003 and in August/September during 2004–2007.

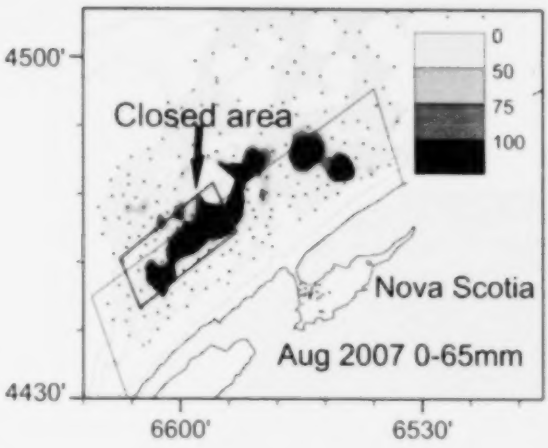


Figure 26. Spatial distribution of catches from the 2007 survey of Scallop Production Areas 1 and 4 for pre-recruit size (<65 mm shell height) scallops. The closed area proposed by the Full Bay Fleet to protect small scallops was implemented on 2 October 2007, as Variation Order 2007-123.

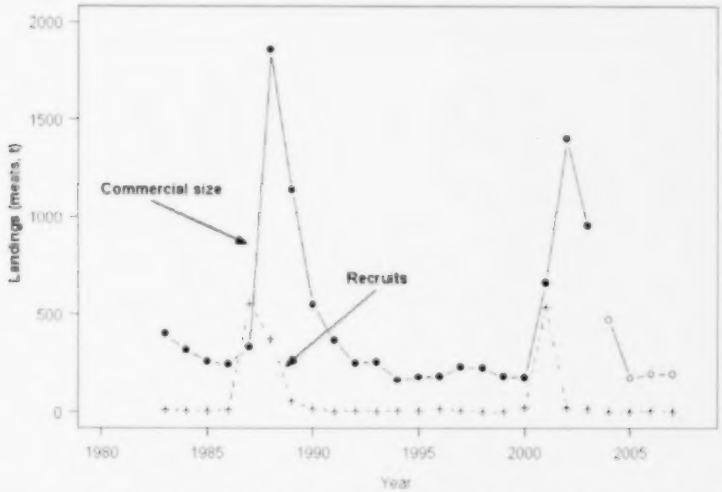


Figure 27. Trends in survey biomass estimates (meats, t) of commercial size (≥ 80 mm shell height) and recruit (65–79 mm shell height) scallops from SPA 4. Break indicates change from June to August surveys in 2004.

As in previous years, a delay-difference model was used to model the dynamics of the SPA 4 scallop population. Population biomass estimated to be 712 t (meats) in 2007 has increased over the estimate for 2006 (672 t) and is below the median biomass of 835.1 t (1983 to 2006).

Last year's predicted biomass for 2007 (using the catch of 68 t) was very close to the biomass predicted for 2007 in this assessment (Figure 28). The prediction for 2008 assumes a catch of 100 t in 2007/2008 and is also dependent upon the average meat weights-at-shell height being similar to that observed in 2007.

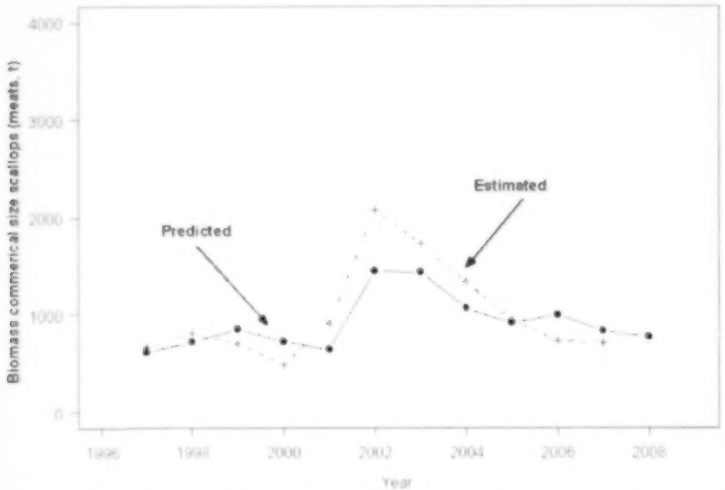


Figure 28. Comparison of predicted biomass from the previous year with the estimated biomass of commercial size (≥ 80 mm shell height) scallops in the current year for SPA 4. Prediction for 2008 made assuming a 2007/2008 catch of 100 t.

Conclusions and Advice

A total catch of 100 t in 2007/2008 is expected to result in a probability of 0.44 that exploitation rates will be greater than 0.20 (Table 9). This catch level is expected to result in an 8% increase in biomass between 2007 and 2008 assuming that meat weight-at-shell height does not change over that time. Given a catch of 100 t in 2007/2008, a total catch of 100 t in 2008/2009 should result in a probability of 0.46 that the exploitation rate will exceed 0.20.

Table 9. Decision table to evaluate catch levels with respect to posterior probability of exceeding exploitation rate of 0.2 for 2007/2008 and 2008/2009.

		Catches in 2008/2009				
Catches in	Pr(e≥0.2)	Pr(e≥0.2) (exploitation)				
2007/08	(exploitation)	50 t	75 t	100 t	125 t	150 t
50 t	0.07 (0.09)	0.12 (0.08)	0.27 (0.13)	0.41 (0.17)	0.52 (0.21)	0.61 (0.25)
75 t	0.26 (0.14)	0.15 (0.09)	0.30 (0.13)	0.44 (0.18)	0.55 (0.22)	0.63 (0.26)
100 t	0.44 (0.18)	0.18 (0.09)	0.33 (0.14)	0.46 (0.18)	0.57 (0.23)	0.65 (0.28)
125 t	0.57 (0.23)	0.21 (0.10)	0.36 (0.15)	0.49 (0.20)	0.59 (0.25)	0.67 (0.30)

SPA 5 – Annapolis Basin

Fishery

The fishery in the Annapolis Basin (SPA 5) is only open to the Full Bay Fleet with the fishing season between 1 January and 31 March. In recent years, landings have varied between 2 and 20 t (Figure 28).

Landings dropped to 2.3 t in 2002 mainly due to increased effort directed towards SPA 4 in the winter. Increased landings in 2003 and 2004 were due to strong recruitment of 1999 and 2000 year-classes (Figure 29). Landings in 2007 were 3.8 t against a TAC of 10 t (Table 10).

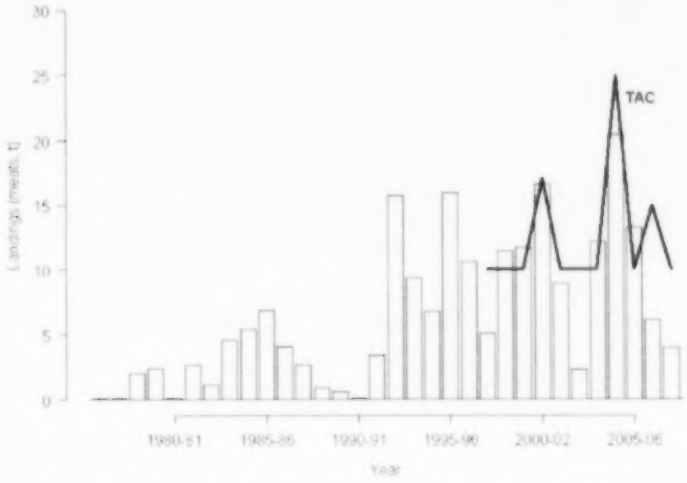


Figure 29. Scallop landings and TAC (meats, t) in SPA 5.

Table 10. Landings and TAC (meats, t) for SPA 5.

Season	Avg. 1998–02	2003	2004	2005	2006	2007
TAC	11.4	10	25	10	15	10
Landings	10.1	12.2	20.4	13.3	6.1	3.8

Resource Assessment

Commercial catch rate in 2007 (10.8 kg/h) was lower than that observed for 2006 (12.5 kg/h) and below the long term median of 19.8 kg/h (1977–2006; Figure 30). The total amount of effort in 2007 was 32 percent lower than that for 2006.

Research vessel surveys have been conducted in Annapolis Basin every June since 1997 except for 2004 when the survey occurred in September. Survey shell height frequencies indicate that the 2004 year-class has started to recruit to commercial size (Figure 31). This year-class is much weaker than the 1999 and 2000 year-classes that contributed to the higher than average commercial size indices in 2002 and 2003, which in turn were reflected by the higher commercial catch rates in those same years (Figure 30). The mean number per tow of commercial size scallops in 2007 exhibited an increase of 50% over 2006 and pre-recruits and recruits were found in low densities throughout the survey area (Figure 32). Recruitment is expected to be below average for the next two years. Meat weight-at-shell height has increased in SPA 5 similar to other areas in the Bay of Fundy.

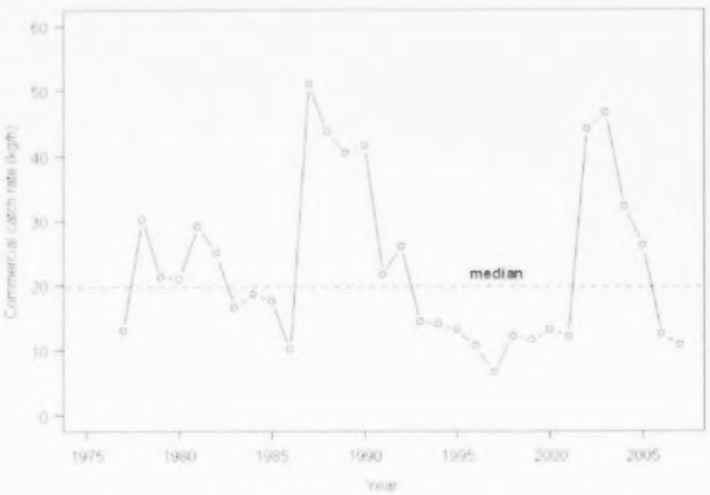


Figure 30. Commercial catch rate (kg/h) for scallops in SPA 5.

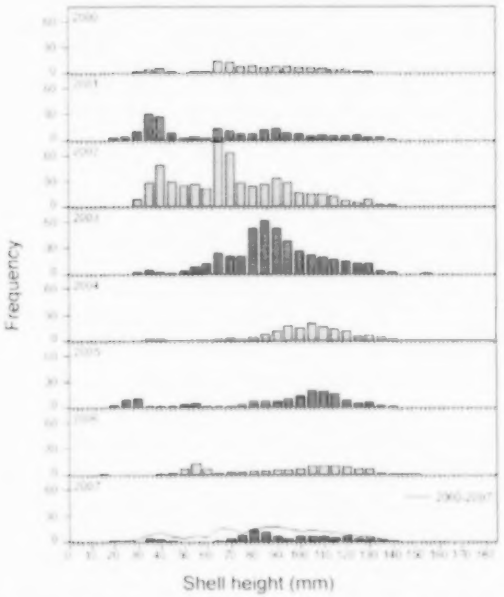


Figure 31. Scallop shell height frequencies (mean no./tow) from surveys of SPA 5.

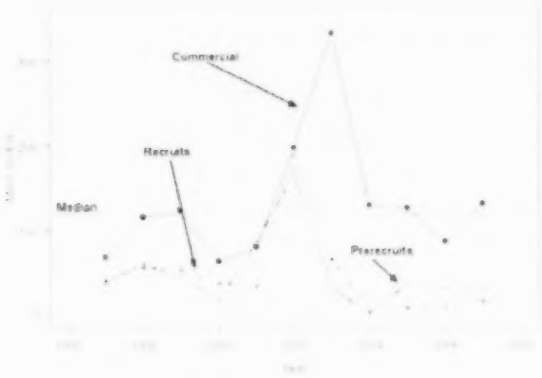


Figure 32. Survey abundance index (mean no./tow) for commercial size (≥ 80 mm shell height), recruit (65–79 mm shell height), and pre-recruit (< 65 mm shell height) scallops in SPA 5.

Conclusions and Advice

A population model has yet to be developed for this SPA. Based on the survey, the abundance of commercial size scallops has increased due the recruitment of the 2004 year class. The commercial size portion of the population (131/tow) is above the 1997–2006 median (120/tow) but little recruitment is expected for the next two years. The TAC for 2008 should not exceed the average catch of 10 t over the period 1997 to 2007 (excluding the high catch in 2004).

SPA 6 - Grand Manan and Southwest New Brunswick

Fishery

The areas around Grand Manan and off southwest New Brunswick are designated SPA 6. This area is further divided into SPAs 6A, 6B and 6C (see detailed map in Appendix 1). Landings to 26 November 2007 were 68 t against a TAC of 140 t (Figure 33, Table 11).

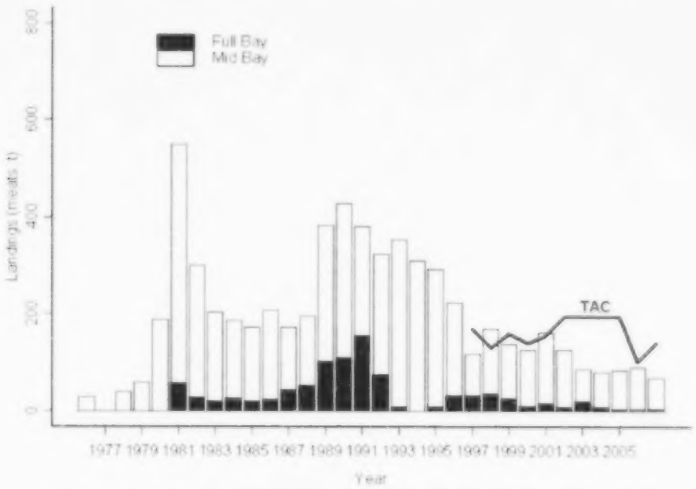


Figure 33. Scallop landings and TAC (meats, t) in SPA 6.

Table 11. Landings and TAC (meats, t) for SPA 6.

Year	Avg. 1998–02	2003	2004	2005	2006	2007[1]
TAC	156	195	195	195	100	140
Landings: FB	19	21	8	5	5	5
Landings: MB	125	66	74	81	86	63

[1] Landings to 26 November 2007.

The 2007 SPA 6 quota for the Full Bay Fleet was 35 t. Full Bay landings by area for 2007 were 2.3 t, 2.5 t, and 0.1 t for SPA 6 A, B and C, respectively. This fleet has not caught its quota for the last six years as it has directed its effort to other areas.

The 2007 quota for the Mid Bay Fleet was 105 t. Mid Bay landings for 2007 by area were 21.7 t, 18.0 t and 23.3 t for SPA 6 A, B, and C, respectively.

Resource Assessment

The commercial catch rate for the Full Bay Fleet increased from 2000 to 2004, but given the low levels of effort, this index may not be tracking changes in the population (Figure 34). The Mid Bay catch rate may be a better reflection of population trends as it is based on somewhat higher levels of effort. As it is, this index does not indicate any large changes in the last 10 years.

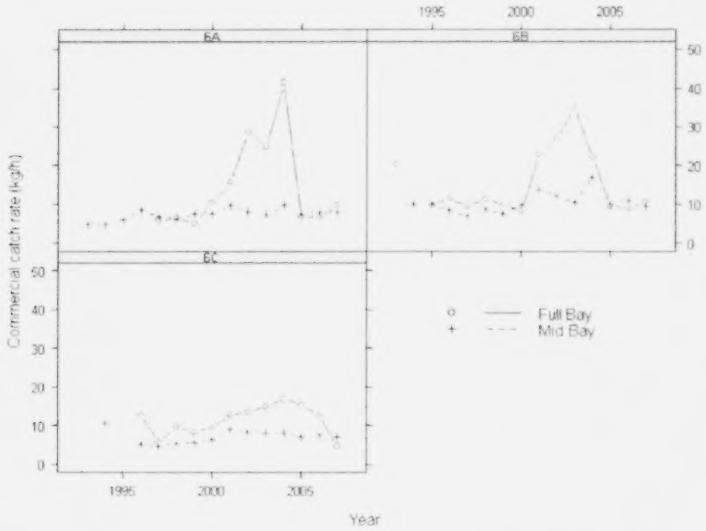


Figure 34. Commercial catch rate (kg/h) for scallops in SPAs 6A, 6B, and 6C.

Average meat weights sampled from the catch are consistent with fishing on an old population with little recruitment.

Research surveys in SPA 6 were initiated in 1979 but discontinued after 1991 until a new series was started in September 1997 which covered 6A and 6B. Stations in 6C were included after 1999. In 2004, mechanical problems with the *CCGC J.L. Hart* resulted in cancelling the survey that year. The Bay of Fundy survey in 2005 was conducted on the *F/V Royal Fundy* and partial coverage of SPA 6 was completed. In 2006, coverage was more extensive with a total of 180 stations allocated to 6A, 6B, and 6C.

In 2006, a repeated or double sampling survey design was used to deal with the patchiness of the distribution of scallops in SPA 6B (Smith et al. 2007). In 2007, this survey design was extended to all areas with 124 survey stations chosen randomly over the area and 45 stations randomly chosen from locations surveyed in 2006. The survey in 6C did not extend along the New Brunswick shore to Mace's Bay.

The survey showed similar distributions of scallops observed in the 2006 survey; however, large catches of small scallops were limited to Duck Island Sound (6B) and Campobello Island (6A; Figure 35). The large numbers of scallops < 65 mm found in the Seal Cove channel and Three Islands (6B) area in 2006 did not appear as 65–79 mm scallops in these areas in 2007.

The shell height frequency for SPA 6A in 2007 indicates that the recruitment detected in 2006 has entered the fishery, but the numbers of potential recruits for 2008 are low relative to estimates in 2006 for 2007 (Figure 36). Scallops with shell heights between 35 and 50 mm appear to be above average in abundance in SPA 6B with most of these scallops located in Duck Island Sound (Figure 37). Relative to the other two areas, 6C has the lowest mean number per tow and little prospects for recruitment (Figure 38).

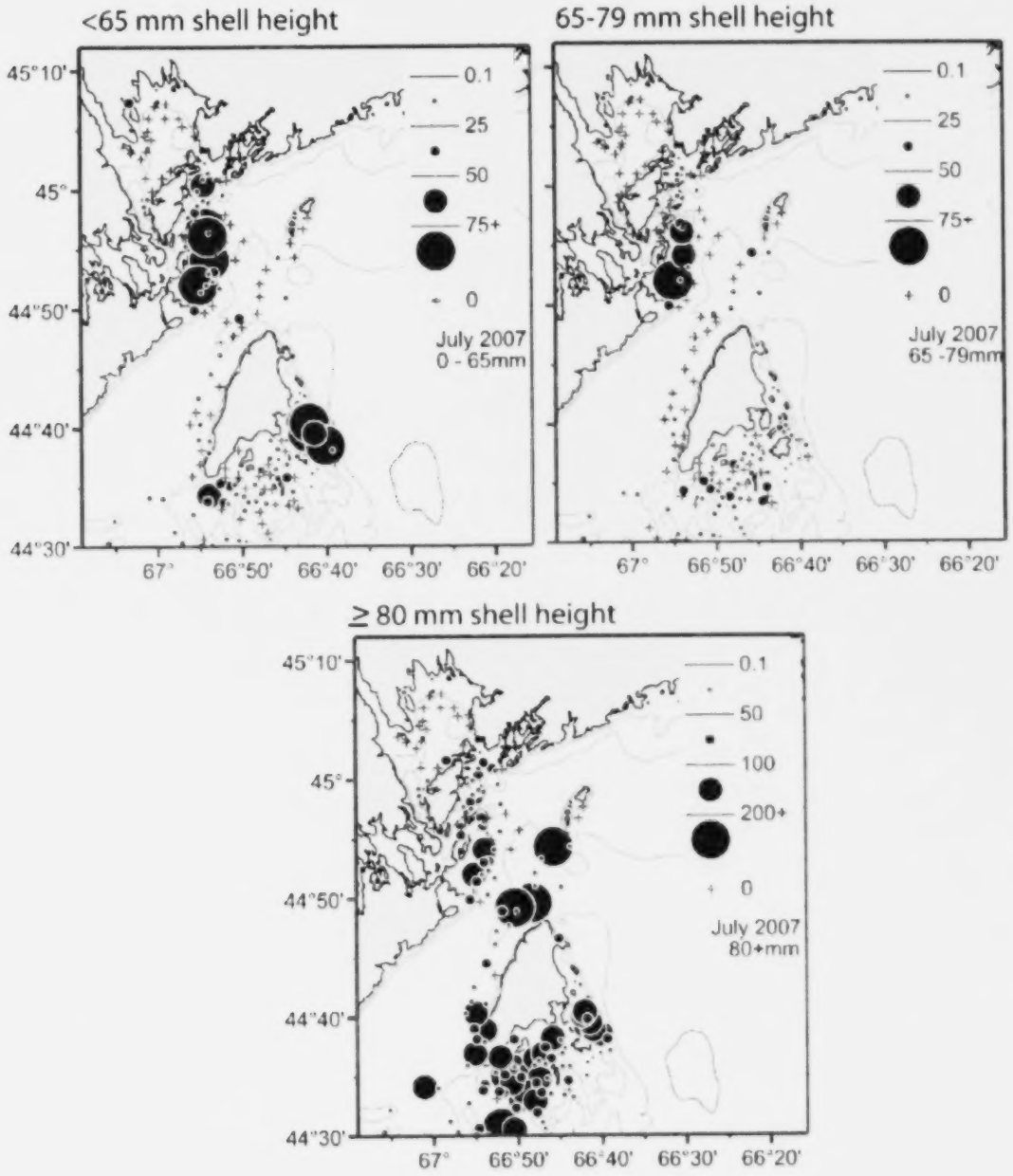


Figure 35. Spatial distribution of scallop catches from the 2006 survey of SPA 6. Top left panel: pre-recruits (< 65 mm shell height); top right panel: recruits (65–79 mm shell height); bottom panel: commercial size (≥ 80 mm shell height).

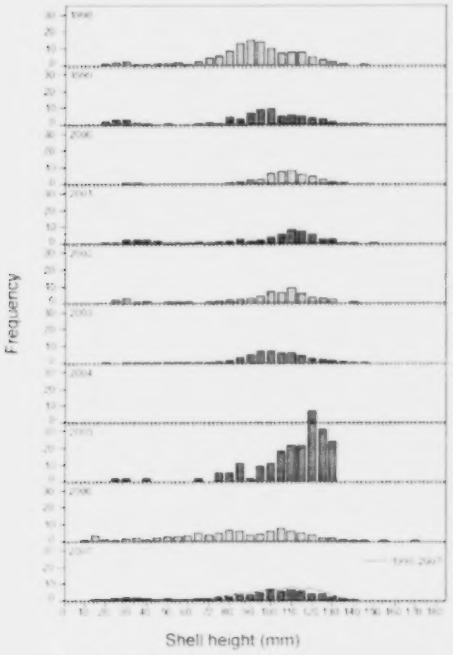


Figure 36. Scallop shell height frequencies (mean no./tow) from surveys of SPA 6A. No survey was conducted in 2004 and the 2005 survey consisted of only 2 tows.

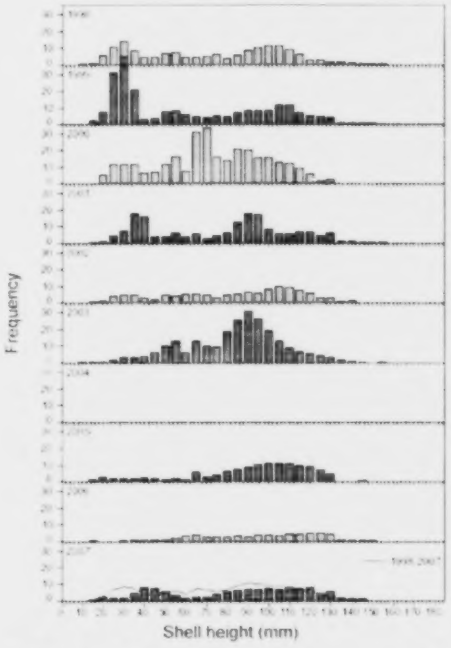


Figure 37. Scallop shell height frequencies (mean no./tow) from surveys of SPA 6B. No survey was conducted in 2004.

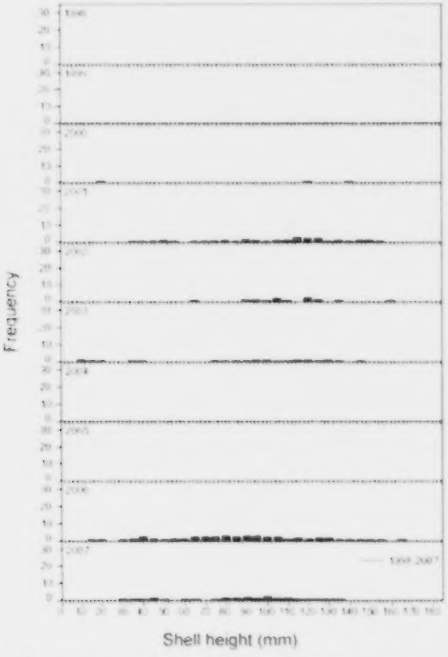


Figure 38. Scallop shell height frequencies (mean no./tow) from surveys of SPA 6C. No survey was conducted in 1998, 1999, 2004 and 2005.

There has been little change in mean numbers per tow of commercial size scallops in 6A (Figure 39). While the 2007 estimate for 6B is similar to 2006, both are significantly lower than 2003 (Figure 40). The 2007 estimate for commercial size scallops in 6C appears to have declined from 2006 (Figure 410). The estimates for 6C may not be indicative of trends in this area due to the small sample sizes in the past and the incomplete coverage of the entire area.

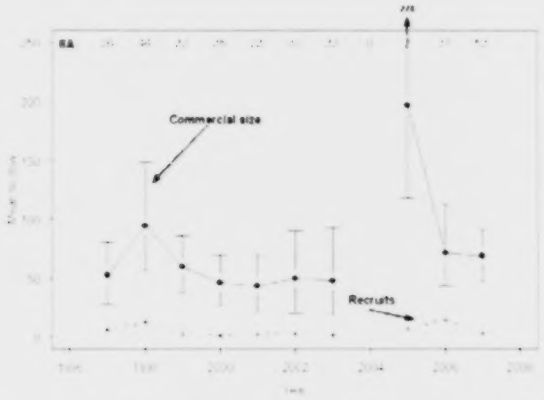


Figure 39. Survey abundance index (mean no./tow) for commercial size (≥ 80 mm shell height) and recruit (65–79 mm shell height) scallops in SPA 6A. Upper and lower limits refer to 95% bootstrap limits. The number of random tows completed each year is given across the top.

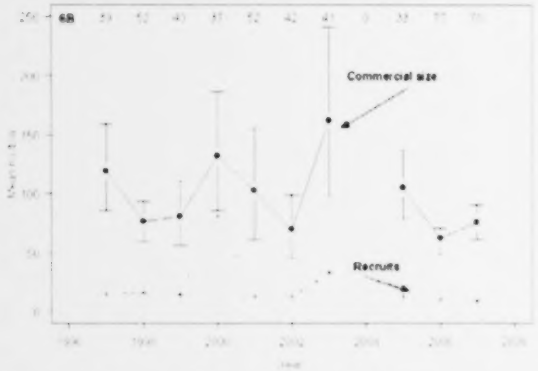


Figure 40. Survey abundance index (mean no./tow) for commercial size (≥ 80 mm shell height) and recruit (65–79 mm shell height) scallops in SPA 6B. Upper and lower limits refer to 95% bootstrap limits. The number of random tows completed each year is given across the top.

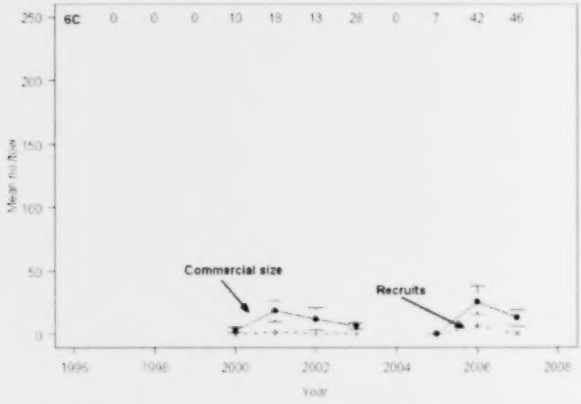


Figure 41. Survey abundance index (mean no./tow) for commercial size (≥ 80 mm shell height) and recruit (65–79 mm shell height) scallops in SPA 6C. Upper and lower limits refer to 95% bootstrap limits. The number of random tows completed each year is given across the top.

Conclusions and Advice

Evidence from the Mid Bay commercial catch rates and the surveys suggest that the abundance of commercial size scallops remains unchanged from 2006 in SPA 6A and 6B and has possibly declined in SPA 6C. Above average recruitment was detected in SPA 6A and 6B; however, in the case of the latter, this recruitment appears to be confined to Duck Island Sound.

There is no evidence to advise increasing the TAC over its current level.

OTHER CONSIDERATIONS

Delayed reporting (logbooks) by the Mid and Upper Bay fleets, although improving, continues to be a problem.

As there has been no observer coverage of the scallop fleets in SPA 1 to 6, there was no means to estimate bycatch of non-scallop species.

The total number of stations covered in the Bay of Fundy and Approaches in 2007 was 703, less than the 855 stations in 2006 but still above the number of stations in recent previous years (520 to 645).

In 2006, attention was focused on the decline in meat weight-at-shell height seen across most areas in the Bay of Fundy and Approaches and the observation that in all areas the average meat weight was below the high recorded in 2001. This year, meat weights have increased and are now close to, or in some cases higher than the 2001 means.

SOURCES OF INFORMATION

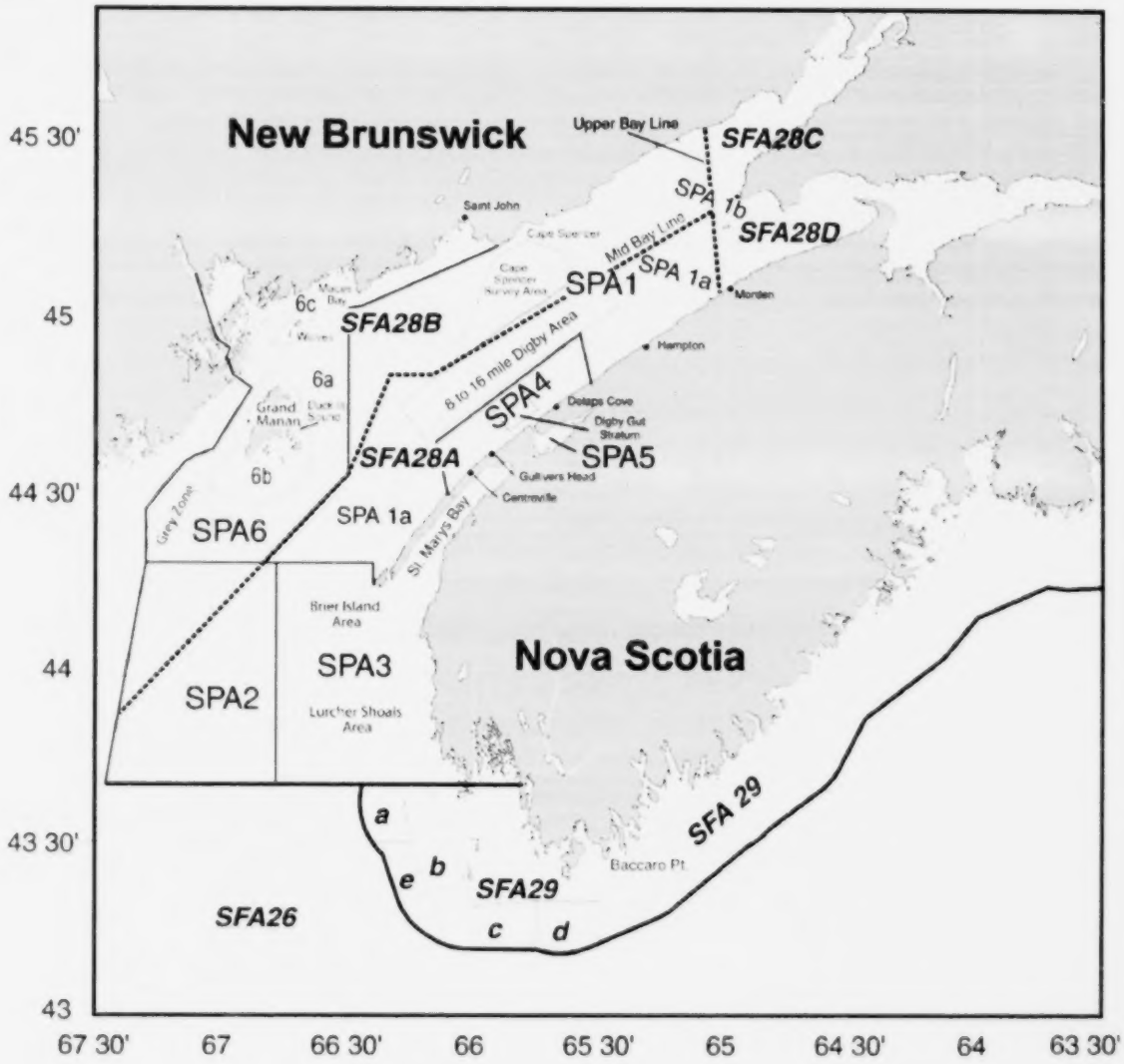
DFO. 2004. Proceedings of the Maritimes Regional Advisory Process Stock Assessment Update of SPA 1,3,4,5 and 6 Scallop Stocks; 8-9 December 2004. DFO Can. Sci. Advis. Sec. Proceed. Ser. 2004/049.

DFO. 2007. Stock Assessment Report on Scallops (*Placopecten magellanicus*) in Scallop Production Areas 1 to 6 in the Bay of Fundy. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2007/013.

Smith, S.J, and M.J. Lundy. 2002. Scallop Production Area 4 in the Bay of Fundy: Stock Status and Forecast. DFO Can. Sci. Advis. Sec. Res. Doc. 2002/018.

Smith, S.J., S. Rowe, and M.J. Lundy. 2007. Scallop Production Areas in the Bay of Fundy: Stock Status for 2006 and Forecast for 2007. DFO Can. Sci. Advis. Sec. Res. Doc. 2007/005.

APPENDIX 1. Locations and place names for inshore scallop grounds.



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